Multi-Volcanic Hazard Impact Assessment for Residential buildings in the Auckland Volcanic Field, New Zealand

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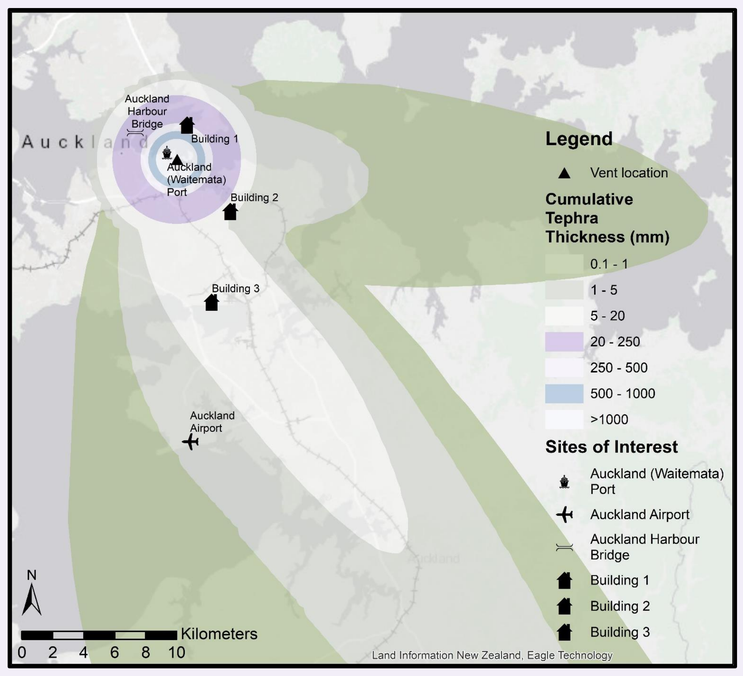
Multi-Volcanic Hazards in Auckland

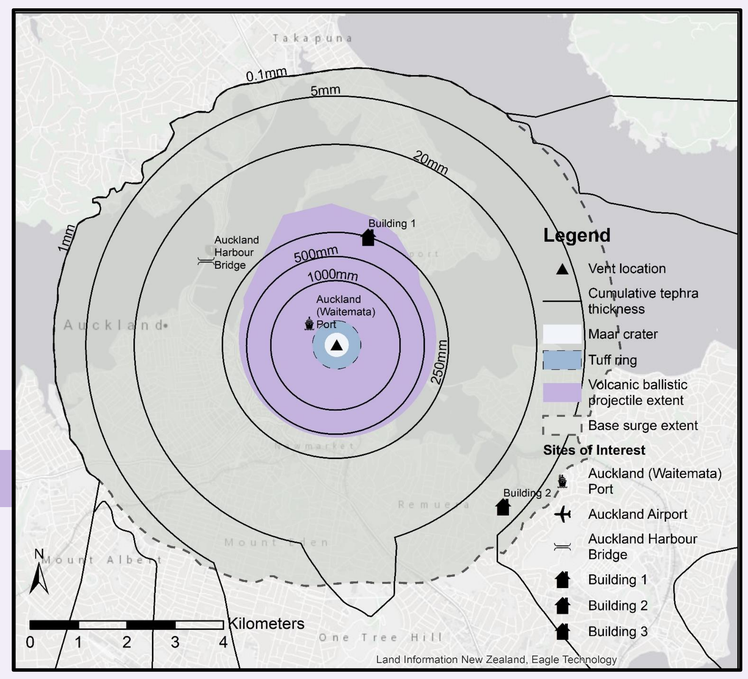


- Conceptual framework designed using scenarios
- Scenarios were developed based on past AVF eruptions, worldwide analogous eruptions, expert elicitation and stakeholder engagement (Hayes et al., 2018).

Waitematā Port Scenario

- 286,436 buildings impacted.
- 87.7% residential,
- 39.6% are impacted by more than 1 hazard.
- Waitematā Port destroyed, airport disrupted

- Volcanic eruptions produce multiple hazards which impact buildings.
- Hazards can vary with time and space.
- The impacts caused by multiple volcanic hazards need to be investigated.
- Hazards in the Auckland Volcanic Field include: earthquakes, volcanic gas, ground deformation, shock wave, tephra fall, base surge/pyroclastic density currents, volcanic ballistic projectiles, lava flows, fire fountaining, edifice construction.



Habitability

- Residential buildings are required to protect residents from inclement weather, structural hazards and disease.
- The impacts of volcanic hazards can influence the habitability of residential buildings.
- It is possible that the order and timing of hazards has a direct relationship with habitability.
- Structural integrity of the building will be the focus of this research.

Roof, with wind protection boulders, covered in ash <500m from 2014 Mt Ontake eruption, Japan. Credit Kae Tsunematsu.

Fire damage from low momentum PDC, 1997 eruption of Soufrière Hills, Montserrat. Credit Baxter, P., (2005), Bul. Volc.

Manual cleaning of tephra in Jacobacci, Argentina, Cordón-Caulle, eruption, 2011. Credit: Aileen Rodriguez.

Conceptual Framework

Common hazard sequence in Auckland

Base surge

PDC damage in periphery zone (≤5kPa), 1997 eruption of Soufrière Hills, Montserrat. Credit Baxter, P., (2005), Bul. Volc.

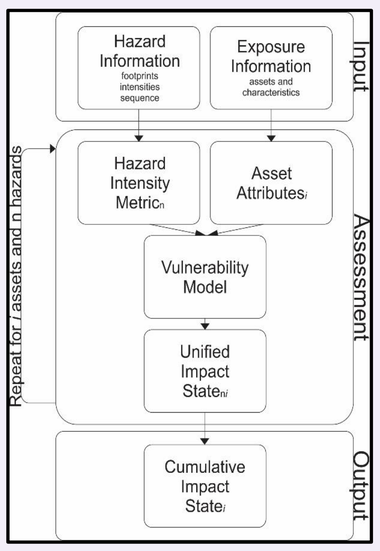
Tephra fall

Purlin failure due to tephra fall from 1994 eruption of Rabaul, Papua New Guinea. Credit Blong, R., (2003), Bul. Volc.

Volcanic ballistic projectiles

Ballistic (and tephra fall) impacts ≈600m from the 2000 eruption of Mt Usu, Japan. Credit Hiromu Okada.

- Develop a conceptual framework to assess the cumulative impact of multiple volcanic hazards.
- Use scenarios to understand sequences of hazards, hazards that commonly occur together.
- Use literature to identify observed hazard interactions.
- Identify gaps in knowledge and conduct laboratory experimentation.

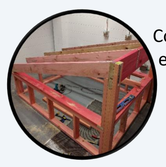


- Unified impact state designed to describe building functionality when impacted by multiple hazards with different damage mechanisms.
- Building functionality can be used to assess many impact metrics (economic loss, structural damage, building habitability).

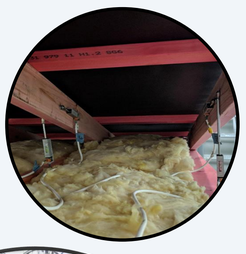
Model of conceptual framework

Experimentation

- Experimental structure designed to represent the largest typology of buildings in the Auckland region.
- Structure is designed to current New Zealand building code and includes roofing and ceiling components.
- Experiments designed to test the vulnerability of components when impacted by tephra fall and ballistic projectiles.
- Testing variables include hazard orders, tephra load, wet and dry tephra, ballistic projectile mass and velocity.
- Measurements of strain will be taken on wooden roofing components.
- Habitability metrics will be developed to determine if the building is likely to be habitable after impact.
- Experiments conducted at University of Canterbury's volcanic impacts laboratory and ballistics "cannon" laboratory.



Construction of the experimental roof



Strain gauges, measuring deflection of wooden roof components

Volcanic ballistic projectile cushioned by 3cm of tephra

Tephra load experimentation using tephra dispersal system and a sample collected from the AVF

Roof loaded with 400kg of tephra sample, maximum thickness of 16cm

Research Questions

- **Will your house be habitable after an Auckland Volcanic Field eruption?**
- What are the possible orders of hazards in a volcanic eruption?
- What impacts are caused to residential buildings when considering multiple hazards?
- Can multiple hazards interact to both increase and reduce impacts to residential buildings.

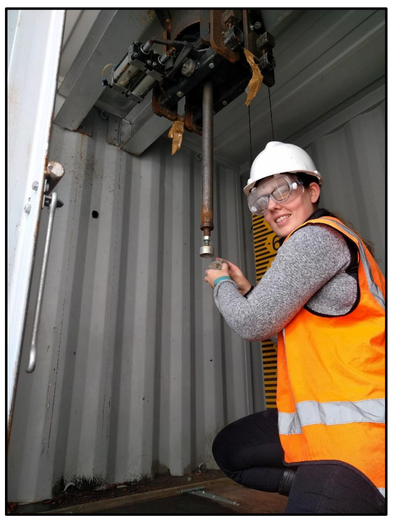
This Research

- Interaction of volcanic ballistic projectiles and tephra fall.
- Assessment of hazard sequences and multi-volcanic hazard framework development.
- Focus on residential buildings with timber-framed construction and sheet metal roof cladding.
- Empirical experimentation to quantify results.

The Auckland Volcanic Field

- Basaltic, monogenetic volcanic field which erupts infrequently with small magma volumes.
- 53 volcanic centres in ~500km^2.
- Oldest eruption ~200ka, youngest eruption ~500 years ago.
- Most commonly produces phreatomagmatic eruptions.

View of Auckland city from Mt Eden.



Me, at the University of Canterbury's ballistics cannon. Credit Ame McSporran.

Watch the University of Canterbury's ballistics cannon in action! Scan the QR code.